

**HIGHLIGHTS OF  
REVISED DRAFT OF  
CHAPTER 7, ON  
LEAD-BASED PAINT  
INSPECTION, OF THE  
HUD *GUIDELINES***

**HUD OFFICE OF LEAD  
HAZARD CONTROL**

**\*\*\* *NOT* \*\*\***  
**HUD POLICY OR  
GUIDANCE**

# **Common Lead-Based Paint Inspection Goals:**

- Locate lead-based paint for abatement purposes
- Locate lead-based paint to prioritize maintenance
- Prove no lead-based paint is present to be exempted from disclosure requirements for leasing
- Investigate exposure sources for lead-poisoned

children(?)

# Questions on Achieving LBP Inspection Goals:

- For each goal, is a different protocol required? ...desirable?
- How to balance simplicity of one protocol vs. complexity of several tailored protocols?
- What compromises are needed to meet different program needs with one protocol?

# **Topic 1**

## Purposes

### **1995 Guidelines:**

Chapter explained LBP inspection methods

### **Suggestion:**

Chapter explicitly notes goals of:

- Determining if LBP is present, and...
- If so, which building components have it
- Explicitly excludes EBL investigation (see chap. 16

or public health officials)

## **Topic 2**

### Spot test kits

#### **1995 Guidelines:**

Not recommended; might be in future

#### **Suggestion:**

Not recommended;  
performance-based decision  
criteria stated (if quality  
demonstrated as at least that  
of XRF analysis)

## **Topic 3**

No. room-equivalents to inspect

### **1995 Guidelines:**

All testing combinations,  
hence all room equivalents

### **Suggestion:**

$\geq 7$  room equivalents:  
child's bedroom (esp. of  
youngest on own), child's  
play area, bathroom, kitchen,  
exterior, 2 most likely w/LBP;  
deteriorated paint; may  
suspend testing if

all components non-LBP

## **Topic 4**

Number of XRF readings per testing combination in single family housing

### **1995 Guidelines:**

3 (if feasible; if not, analyze paint chip)

### **Suggestion:**

1 (if feasible; if not, analyze paint chip), but 3 walls (or all walls if no clear LBP-vs.-non-LBP pattern)

## **Topic 5**

Multifamily housing: number of units sampled

### **1995 Guidelines:**

For pre-1978 housing, 95% confidence that finding no LBP in sampled units indicates that under 5% of all units have lead-based paint components

### **Suggestion:**

For 1960-77 housing, 95% confidence that finding of no LBP in sampled units indicates that under 10% of all units have lead-based

# paint components

<b>No. MF Units</b>	<b>Test: Pre-'60 or Unk.</b>	<b>Test: '60-'77</b>
<b><math>\leq 16</math></b>	<b>All</b>	<b>All</b>
<b>20</b>	<b>All</b>	<b>16</b>
<b>40</b>	<b>31</b>	<b>21</b>
<b>60</b>	<b>38</b>	<b>23</b>
<b>100</b>	<b>45</b>	<b>25</b>
<b>600</b>	<b>56</b>	<b>28</b>
<b>1000</b>	<b>57</b>	<b>29</b>
<b><math>&gt; 1000</math></b>	<b>5.8%</b>	<b>2.9%</b>

## **Topic 6**

### Inspection procedures

#### **1995 *Guidelines*:**

Provided considerable detail to young industry

#### **Suggestion:**

Provide more general detail to the more developed industry

Please send comments on the draft, **specifying the page and line numbers** you are commenting on, by **June 9**, to:

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(Please send a version of your comments as a WordPerfect 5.1 file or text file on 3-1/2" disk with your paper copy).

or

Warren\_Friedman@HUD.gov  
(WordPerfect 5.1 file or text file **only**).

The current Chapter 7, this draft, other HUD and EPA lead documents are available on HUD's Web home page:

**[www.hud.gov/lea/leahome.html](http://www.hud.gov/lea/leahome.html)**

Get paper copies of documents from HUDUSER, at **800-245-2691**.

Many lead-based paint questions can be answered by the National Lead Information Center (NLIC) Clearinghouse, jointly funded by HUD and EPA, at **800-424-LEAD**.

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## Lead-Based Paint Inspection: How to Do It (Summary)

1. Determine if lead-based paint inspections should be conducted (see Chapter 5). A lead-based paint inspection will determine:
  - Whether lead-based paint is present in a house, dwelling unit, residential building, or housing development, including common areas and exterior surfaces; and
  - If present, which building components contain lead-based paint.
2. Hire a certified (licensed) lead-based paint inspector and, if necessary, select a laboratory recognized under the U.S. Environmental Protection Agency (EPA) National Lead Laboratory Accreditation Program (NLLAP) for paint-chip analysis. Lists of inspectors and laboratories can be obtained by calling 1-888-LEADLIST or through the internet at [www.leadlisting.org](http://www.leadlisting.org). Lists are also available through State agencies (call 1-880-LEAD-FYI for the appropriate local contact). More than half of all States now require a license or certification to perform a lead-based paint inspection.
3. Determine whether the standard for lead-based paint in the jurisdiction is different from the U.S. Department of Housing and Urban Development (HUD) standard, which is 1.0 mg/cm<sup>2</sup> or 0.5 percent by weight (5,000 ppm by weight). The procedures in this chapter are referenced to the HUD standard. If a different local standard applies, these procedures will need to be modified.
4. Reporting lead paint concentrations in mg/cm<sup>2</sup> is recommended because this unit of measurement does not depend on the number of layers of non-lead-based paint. All measurements of lead in paint should be in mg/cm<sup>2</sup>, except when it is not possible for the technical reasons explained in this chapter.
5. When used according to the manufacturer's instructions and the *XRF Performance Characteristics Sheet* for the specific model being used, portable X-ray Fluorescence (XRF) lead-based paint analyzers are usually capable of determining if lead-based paint above or below the HUD standard. The *XRF Performance Characteristics Sheet* will specify the ranges where XRF results are inconclusive, calibration check tolerances, and other important information. Contact the National Lead Information Center Clearinghouse (1-800-424-LEAD) to obtain the appropriate *XRF Performance Characteristics Sheet*, or download it from the internet at [www.hud.gov/lea/leahome.html](http://www.hud.gov/lea/leahome.html). Performance characteristics sheets are available for most commercially available XRFs.
6. Observe radiation safety procedures when using XRF instruments.
7. Before beginning an inspection, take at least three calibration check readings. Additional calibration check readings should be made every 4 hours or after inspection work has been completed for the day or according to the manufacturer's instructions, whichever is more frequent. Calibration checks should always be done before the instrument is turned off and again after it has been warmed up. Calibration check tolerances are obtained from the *XRF performance characteristics sheet*.
8. When conducting an inspection in a multifamily housing development or building, obtain a complete list of all housing units and determine which can be grouped for inspection purposes based on similarity of construction materials and common painting histories. In each group of similar units, the inspector should determine the minimum number to be inspected from the tables in this chapter. Specific units to inspect are selected randomly.

At least 10 similar common areas, 10 similar exterior building sides, and 10 similar exterior site areas associated with the selected units should be selected according to the procedures in this chapter.

9. For each unit to be inspected, inventory all painted components in each room equivalent, including exterior surfaces and selected common areas. Painted surfaces include any surface coated with paint, shellac, varnish, stain, paint covered by wallpaper, or any other coating.
10. Take XRF readings on all testing combinations in at least 7 room equivalents, to be selected according to the guidance in this chapter.
11. A testing combination is characterized by the room equivalent, the component type, and the substrate. A different visible color does not necessarily result in a separate testing combination. Take at least one individual XRF reading on each testing combination in each room equivalent tested, except for walls, where at least three readings should be taken. Take each reading on a separate wall. It is not necessary to take multiple XRF readings on the same spot, as was previously recommended in the 1990 Interim Guidelines for Public and Indian Housing.
12. Determine whether to correct the XRF readings for substrate interference by consulting the *XRF Performance Characteristics Sheet* and by reviewing testing results. If test results fall within the range that indicates substrate correction is necessary, take readings on surfaces scraped completely clean of paint. The correction value is an average of six readings taken on two randomly selected test locations (three readings on each location) in a single-family house or in two units in a multifamily development for each type of substrate requiring correction.
13. In single-family housing inspections, XRF results are classified negative, positive, or inconclusive based on the applicable *XRF Performance Characteristics Sheet*. All inconclusive readings must be confirmed in the laboratory, unless the owner wishes to assume that all inconclusive results are positive. Such an assumption may reduce the cost of inspection, but it will probably increase subsequent abatement, interim control, and maintenance costs.
14. In multifamily dwelling inspections, XRF readings are evaluated using the same rules that apply to single-family housing, except that they are aggregated across units and room equivalents by component type. Use the flowchart provided in this chapter to make final classifications of all testing combinations or component types in the development based on the percentages of positive, negative, and inconclusive readings.
15. If it is necessary to collect paint-chip samples, they should be analyzed by a laboratory recognized under the National Lead Laboratory Accreditation Program. Paint-chip samples are collected to confirm analysis when the overall results for a component type are inconclusive. They may be collected by a properly trained inspector, owner, or third party. Paint-chip samples should contain all layers of paint and must always include the bottom layer. If results will be reported in mg/cm<sup>2</sup>, including substrate with the sample will not significantly affect results. Substrate material should not, however, be included in samples reported in weight percent. Paint from 4 square inches (25 square centimeters) should provide a sufficient quantity for laboratory analysis, although less may be collected if the laboratory indicates a smaller sample is acceptable.
16. The quality of the inspection should be evaluated by the owner or owner's representative using the procedures in this chapter.
17. The inspection report should include a summary indicating if and where lead-based paint is located in the unit or the housing development (or building) and a statement that the results must be disclosed to potential new buyers and renters (lessees) prior to obligation under a sales contract or lease, based on Federal law (24 CFR Part 35 and 40 CFR Part 745). To facilitate compliance with the HUD/EPA Requirements for the Disclosure of Lead-

Based Paint and/or Lead-Based Paint Hazards, recommended inspection report language is provided in this chapter. The report should contain the following information:

- Housing unit identifiers;
- Date of the inspection;
- Identity of the inspector and the inspection firm and any relevant certifications or licenses held by the inspector and/or the firm;
- Building component and room equivalent identification or numbering system, or sketch used in the inspection;
- All XRF readings (including calibration check readings);
- All paint chip analyses;
- Testing protocol used;
- Instrument manufacturer, model, serial number, mode(s) of operation, and age of the radioactive source;
- Final classifications of all painted or coated building components in each room equivalent into positive, negative, or inconclusive categories (including a list of surfaces and room equivalents that were classified but not individually tested); and
- Information on the owner's legal obligation to disclose inspection results to tenants and/or purchasers under 24 CFR Part 35 and 40 CFR Part 745 (published in the *Federal Register*, Volume 61, Number 45, March 6, 1996, starting on p. 9064).

The summary report should answer two questions: (1) Is there lead-based paint in the house? And, (2) If lead-based paint is present, where is it located? The summary report should also include the address of the house where the inspection was performed; the date(s) of the inspection; the name, address, and telephone number of the inspector or inspection firm; the appropriate license or certification number; and the starting and ending times for each day when XRF testing was done. The summary should also contain the following language regarding disclosure:

"A copy of this summary must be provided to new lessees (tenants) and purchasers of this property under Federal law (24 CFR Part 35) before they become obligated under a lease or sales contract. The complete report must also be provided to new purchasers and it must be made available to new tenants. Landlords (lessors) and sellers are also required to distribute an educational pamphlet and include standard warning language in their leases or sales contracts to ensure that parents have the information they need to protect their children from lead-based paint hazards. This report will be kept by the inspector and should also be kept by the owner and should be passed on to all future owners."

If no lead-based paint has been detected in the house, the summary should say so. The following language may be used:

"The results of this inspection indicate that no lead in concentrations greater than or equal to 1 mg/cm<sup>2</sup> in paint was found on any building components, using the inspection protocol in Chapter 7 of the HUD *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*. Therefore, this dwelling qualifies for the exemption in 24 CFR Part 35 for leased target housing that is free of lead-based paint. However, some painted surfaces may contain levels of lead below 1 mg/cm<sup>2</sup>, which could create lead dust or lead-contaminated soil hazards if the paint is turned into dust by abrasion, scraping, or sanding. This report will be kept by the inspector and should also be kept by the owner and should be passed on to all future owners."

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**1** Addendum 1 at the end of this chapter contains updated *XRF Performance Characteristics Sheets* for most  
**2** commercially available XRF lead-based paint analyzers. The data collection forms contained in Addendum 2,  
**3** comparable forms, or equivalent computerized reports can be used to document the results of an inspection.

## Chapter 7: Lead-Based Paint Inspection

### **I. Introduction**

#### **A. Purpose**

This chapter explains methods for performing lead-based paint inspections in housing to determine:

- Whether lead-based paint is present in a house, dwelling unit, residential building, or housing development, including common areas and exterior surfaces; and
- If present, which building components contain lead-based paint.

The information presented is intended for both inspectors and persons who purchase inspection services. Both an inspection protocol and methods for determining the quality of an inspection are provided. Ways of finding and listing inspectors are also described.

#### **1. Disclosure of Inspections**

Federal law now requires that the results of lead-based paint inspections and risk assessments be disclosed to renters (lessees) entering into a new lease (or renewing an old lease) and to purchasers prior to obligation if lead-based paint is found. If the inspection described in this chapter finds that lead-based paint is not present, the dwelling unit and all other dwelling units characterized by the inspection are exempt from disclosure requirements. See 24 CFR Part 35 and 40 CFR Part 745 for additional details. See Section IV for recommended inspection report language regarding these disclosure requirements.

#### **2. Limitations of This Inspection Protocol**

The protocol described here is not intended for investigating housing units where children with elevated blood lead levels are currently residing. Such a protocol can be found in Chapter 16 or may be available from a State or local health department.

#### **3. Documentation of Results**

The complete set of forms provided at the end of this chapter may be used in single-family and multifamily housing. Equivalent forms or computerized reports may also be used to document the results of inspections.

### **B. Qualifications of Inspectors and Laboratories**

#### **1. Where to Find Inspectors and Laboratories**

Lists of State-licensed (certified) inspectors and accredited laboratories recognized under the U.S. Environmental Protection Agency (EPA) National Lead Laboratory Accreditation Program (NLLAP) are often available from State or local agencies. Call the National Lead Information Center Clearinghouse (1-800-424-LEAD) to locate the appropriate local contact.

1 A nationwide listing of certified inspectors, risk assessors, and accredited laboratories is also available on the internet  
2 at [www.leadlisting.org](http://www.leadlisting.org). The lists are also available through an automated telephone system by calling 1-888-  
3 LEADLIST (1-888-532-3547).  
4

## 5 **2. Qualifications of Inspectors**

6 The inspector must be certified (licensed) in lead-based paint inspection by the State where the testing is to be done if  
7 it has an inspection certification program; if the State does not have such a program, the inspector should be certified  
8 by another State. Currently, more than half of all States have such licensing laws.  
9

## 10 **C. Other Sources of Information Required to Use This Protocol**

11 The other sources of information needed for using this protocol include an *XRF performance characteristics sheet*,  
12 State radiation protection regulations, and American Society for Testing and Materials (ASTM) and National Institute  
13 for Standards and Testing (NIST) standards.  
14

### 15 **1. XRF Performance Characteristics Sheet**

16 An *XRF performance characteristics sheet* defines acceptable operating specifications and procedures for each model  
17 of X-Ray Fluorescence (XRF) lead-based paint analyzer. An inspector must follow the performance characteristics  
18 sheet to comply with this protocol. For most commercially available XRFs, performance characteristics sheets are  
19 available from the National Lead Information Center Clearinghouse or through the internet at  
20 [www.hud.gov/lea/leahome.html](http://www.hud.gov/lea/leahome.html). They are also included in a new, easy-to-read format in Addendum 1 to this  
21 chapter.  
22

### 23 **2. XRF Radiation Protection Regulations**

24 Regulations that govern radioactive sources used in XRFs are available from State radiation protection agencies.  
25

### 26 **3. ASTM and NIST Standards**

27 Other helpful information and standards are available from ASTM(610-832-9585), including:  
28

- 29 • ASTM E 1729 on collection of paint-chip samples;
- 30 • ASTM E 1583 on evaluating laboratories used to determine lead levels;
- 31 • ASTM E 1645 on laboratory preparation of paint-chip samples; and
- 32 • ASTM E 1613 on analysis of samples for lead.

33 NIST(301-975-6776) has also developed a series of paint films that have known amounts of lead-based paint and can  
34 be used for calibration check purposes (NIST Standard Reference Material 2579).  
35

## 36 **D. Paint Testing for Inspections and Risk Assessments**

37 Risk assessments determine the presence of lead-based paint *hazards*, while inspections determine the presence of  
38 lead-based paint. The paint-chip sampling and measurement techniques used for paint inspection are similar to the  
39 techniques used for risk assessment. However, the number of paint measurements or samples taken for a paint  
40 inspection is considerably greater than the number of paint samples required for a risk assessment, because risk  
41 assessments measure lead only in deteriorated paint, dust, and soil. Inspections measure lead in both deteriorated and  
42 intact paint, which involves many more surfaces. Risk assessments always note the condition of paint films;  
43 inspections may not. See Chapter 5 for methods to determine paint film condition.  
44

#### E. Primary Inspection Method

Portable XRF lead-based paint analyzers are the most common primary analytical method for inspections in housing because of their demonstrated abilities to determine if lead-based paint is present on many surfaces and to measure the paint without destructive sampling or paint removal, as well as their high speed and low cost per sample. Portable XRF instruments expose the painted surface to X rays or gamma radiation, which causes lead to emit X rays with a characteristic frequency or energy. The intensity of this radiation is measured by the instrument and then converted into the area loading (also called area concentration) of lead in the paint, which is described as milligrams of lead per square centimeter of surface area ( $\text{mg}/\text{cm}^2$ ).

#### F. XRF Performance Characteristics Sheets and Manufacturer's Instructions

Only XRF instruments that have an *XRF Performance Characteristics Sheet* should be used. XRFs must be used in accordance with the manufacturer's instructions and the performance characteristics sheet. The performance characteristics sheet contains information about XRF readings taken on specific substrates, calibration check tolerances, and other aspects of the model's performance. If discrepancies exist between the performance characteristics sheet or the *HUD Guidelines* and the manufacturer's instructions, the more stringent guidelines should be followed. For example, if the performance characteristics sheet has a lower calibration check tolerance than the manufacturer's instructions, the performance characteristics sheet should be followed. These *Guidelines* and the *XRF Performance Characteristics Sheets* are applicable to all XRF instruments that detect K X rays, L X rays, or both.<sup>1</sup>

#### G. Inspection by Paint Chip Analysis

In theory, all paint inspections could be carried out using paint-chip sampling and laboratory analysis. However, this is not recommended because it is time-consuming, costly, and requires extensive repair of painted surfaces. Laboratory analysis of paint-chip samples is recommended for inaccessible or building components with irregular (non-flat) surfaces that cannot be tested using XRF instruments. Laboratory analysis is also recommended to confirm inconclusive XRF results, as specified on the applicable performance characteristics sheet. Only laboratories recognized under the EPA NLLAP should be used.

Laboratory analysis is more accurate and precise than XRF but only if great care is used to collect and analyze the paint-chip sample. Like XRF readings, laboratory results should be reported as  $\text{mg}/\text{cm}^2$ . Appendix 1 explains why units of  $\text{mg}/\text{cm}^2$  are not dependent on the number of overcoats of lead-free paint and why such units of measure are therefore more reliable than weight percent. The dimensions of the area from which a paint-chip sample was removed must be measured as accurately as possible (to the nearest millimeter or 1/16th of an inch).

Although laboratory results can also be reported as a percentage of lead by weight of the paint sample, percents should only be used when it is not feasible to use  $\text{mg}/\text{cm}^2$ . These two units of measure are not interchangeable. Laboratory results should be reported as  $\text{mg}/\text{cm}^2$  if the surface area can be accurately measured and if all paint within that area is collected.

---

***Most XRF instruments detect K-shell fluorescence (X-ray energy), some L-shell fluorescence, and some K and L fluorescence. In general, L X rays released from greater depths of paint are less likely to reach the surface than are K X rays, which makes detection of lead in deeper paint layers by L X rays alone more difficult. However, L X rays are less likely to be influenced by substrate effects.***

In mg/cm<sup>2</sup> measurements, including substrate material with the sample does not affect the results significantly. In weight percent measurements, however, no substrate can be included because it will likely "dilute" the amount of lead reported. Regardless of the units of measure selected, the bottom layer of paint must always be included in the sample. If the bottom layer of paint appears to have "bled" into the substrate, the upper portion of the substrate must be included in the sample to ensure that all lead within the sample area has been included in the sample. In such cases, the results should always be reported in mg/cm<sup>2</sup>.

See Section VI for additional information on laboratory analysis.

## **H. Other Means of Analyzing Paint**

Other methods of analyzing lead in paint are available, including transportable instruments and chemical test kits. Because these methods involve paint removal, some repair is needed after sampling (see Section VI).

### **1. Mobile Laboratories**

Portable instruments that employ anodic stripping voltammetry and potentiometric stripping analysis are now available. If the organization or individual using them is recognized under the EPA NLLAP, they can be used in the same way as any other accredited laboratory. In short, both fixed-site and mobile laboratories may be used, provided they are recognized under NLLAP.

### **2. Chemical Test Kits**

One type of chemical test kit is based on the formation of black lead sulfide when lead in paint reacts with sodium sulfide. Another is based on the formation of a red or pink color when lead in paint reacts with sodium rhodizonate.

EPA has found that chemical spot test kits are unreliable (EPA 1995) and should not be used. HUD and EPA could recommend them in the future if chemical test kit technology becomes equivalent to XRF or laboratory paint chip analysis in their ability to properly classify painted surfaces into positive, negative, and inconclusive categories, with estimates of the magnitude of sampling and analytical error. Performance characteristics sheets currently provide such estimates for XRFs and analytical error is well-described for laboratory analysis. Were a chemical spot test kit shown by research independent of the manufacturer and users to have a sampling and analytical error equivalent to (or less than) XRF, HUD and EPA might consider recommending its use. For example, if a test kit were shown to be equivalent to XRF testing for false negatives, then it could be used as a negative screen test (that is, a chemical spot test kit could possibly be used to determine the absence of lead-based paint but not its presence). HUD is currently funding the National Institute for Standards and Technology (NIST) to evaluate commercially available chemical test kits. Information on test kits or other new technologies for testing for lead in paint can be obtained from the National Lead Information Center Clearinghouse (1-800-424-LEAD).

## **II. Summary of XRF Radiation Safety Issues**

Radiation hazards associated with use of XRFs are covered in detail in Section VII. An XRF must never be pointed at anyone, even if the shutter is closed. Inspectors should wear radiation dosimeters to measure their exposure, although excessive exposures are highly unlikely if the instruments are used in accordance with the manufacturer's instructions. Persons should not be near the other side of a wall, floor, ceiling, or other surface during testing. Exposure to radiation will be far below applicable limits when XRFs are used in accordance with the manufacturer's instructions.

## **III. Definitions**

Lead-based paint - Lead-based paint means paint or other surface coatings that contain lead equal to or greater than 1.0 mg/cm<sup>2</sup> or 0.5 percent by weight (equivalent units are: 5,000 µg/g, 5,000 mg/kg, or 5,000 ppm by weight). Surface coatings include paint, shellac, varnish, or any other coating, including wallpaper which covers painted surfaces.

Room equivalent - A room equivalent is an identifiable part of a residence, such as a room, a house exterior, or an exterior area. Closets or other similar areas adjoining rooms should not be considered as separate room equivalents unless they are obviously dissimilar from the adjoining room equivalent. Most closets are not separate room equivalents. Exteriors should be included in all inspections. An individual side of an exterior is not considered to be a separate room equivalent, unless there is visual or other evidence that its paint history is different from that of the other sides. All sides of a building (typically two for row houses or four for freestanding houses or apartment buildings) are generally treated as a single room equivalent if the paint history appears to be similar.

Substrate - The substrate is the material underneath the paint. Substrates should be classified into one of six types: brick, concrete, drywall, metal, plaster, or wood. These substrates cover almost all building materials that are painted and are linked to those used in the XRF performance characteristics sheets. For example, the concrete substrate type includes poured concrete, precast concrete, and concrete block.

If a painted substrate exists that is different from the substrate categories shown on the *XRF Performance Characteristics Sheet*, select the substrate type that is most similar in density and composition to the substrate being tested. For example, for painted glass substrates, an inspector should select the concrete substrate, because it has about the same density (2.5 g/cm<sup>3</sup>) and because its major components are similar to silicon.

For components that have layers of different substrates, such as plaster over concrete, the substrate immediately adjacent to (underneath) the painted surface should be used. For example, plaster over concrete block is recorded as plaster.

Testing Combination - A testing combination is a unique combination of room equivalent, building component type, and substrate. Visible color is often not an accurate predictor of painting history and is not included in the definition of a testing combination.

Table 7.1 lists common building component types that could make up distinct testing combinations within room equivalents. The list is not intended to be complete. Unlisted components that are coated with paint, varnish, shellac, wallpaper, stain, or other coating should also be considered as a separate testing combination.

Table 7.1 Examples of Interior and Exterior Building Component Types

Commonly Encountered Interior Painted Components That Should Be Tested Include:	
Air Conditioners	Fireplaces
Balustrades	Floors
Baseboards	Handrails
Bathroom Vanities	Newel Posts
Beams	Other Heating Units
Cabinets	Radiators
Ceilings	Shelf Supports

1  
2  
3  
4  
5  
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7  
8

Chair Rails	Shelves
Columns	Stair Stringers
Counter Tops	Stair Treads and Risers
Crown Molding	Stools and Aprons
Doors and Trims	Walls
Electrical Fixtures	Window Sashes and Trims

Exterior Painted Components That Should Be Tested Include:	
Air Conditioners	Handrails
Balustrades	Lattice Work
Bulkheads	Mailboxes
Ceilings	Painted Roofing
Chimneys	Railing Ca[s
Columns	Rake Boards
Cornerboards	Sashes
Doors and Trim	Siding
Fascias	Soffits
Floors	Stair Risers and Treads
Gutters and Downspouts	Stair Stringers
Joists	Window and Trim

Other Exterior Painted Components Include:	
Fences	Painted Curbing and Signs
Lampposts	Storage Sheds & Garages
Laundry Line Posts	Swing sets and Other Play Equipment

Table 7.2 provides five examples of different testing combinations. The first example is a wooden bedroom door. This is a testing combination because it is described by a room equivalent (bedroom), component (door), and substrate (wood). If one of these variables changes, it is considered to be a separate testing combination. For example, if a second door in the room equivalent is metal, two testing combinations, not one, would be present.

For doors separating rooms, each side of the door is assigned a separate room equivalent and tested separately. The same is true of door casings.

Table 7.2 Examples of Distinct Testing Combinations

Room Equivalent	Building Component	Substrate
Bedroom 1	Door	Wood
Bedroom 1	Door	Metal
Kitchen	Wall	Plaster
Garage	Floor	Concrete
Exterior	Siding	Wood
Exterior	Swing set	Metal

Building Component Types - A building component type consists of doors, windows, walls, and so on that are repeated in more than one room equivalent in a unit. If a unique building component is present in only one room, it is considered to be a testing combination. Each testing combination may be composed of more than one building component (such as two similar windows within a room equivalent). Component types can be located inside or outside the dwelling. For example, typical component types in a bedroom would be the ceiling, walls, a door and its casing, the window sash, window casings, and any other distinct surface, such as baseboards, crown molding, and chair rails. If patterns are found among building component types in different room equivalents, an inspection report may summarize results by building component type, as long as all measurements are included in the report. For example, the inspection may find that all doors and door casings in a dwelling unit were positive.

Inventory - A completed inventory includes a list of all coated building components in all room equivalents within a dwelling unit.

Test Location - The test location is a specific area on a testing combination where either an XRF reading or a paint-chip sample will be taken.

#### **IV. Inspections in Single-Family Housing**

Single-family housing inspections are conducted using the following seven steps:

- Inventory all painted building components, including components that are stained, shellacked, varnished, coated, or painted and covered with wallpaper.
- Select testing combinations.
- Perform XRF testing (including the calibration check readings).
- Collect and analyze paint-chip samples for testing combinations that cannot be tested with XRF or that had inconclusive XRF results.
- Classify XRF and paint-chip results.
- Evaluate the work and results to ensure the quality of the paint inspection.
- Document all findings in a plain language summary and a complete report; include language in both the summary and the report indicating that the information must be disclosed to tenants and prospective purchasers in accordance with Federal law (24 CFR Part 35 and 40 CFR Part 745).

##### **A. Inventory and Selection of Painted Surfaces**

Conduct an inventory of all painted surfaces in all interior rooms, on all exterior building surfaces, and on surfaces in other exterior areas, such as fences, playground equipment, and garages. The "Single-Family Housing LBP Testing Data Sheet" (see forms at the end of this chapter) or a comparable data collection instrument may be used for this purpose. An inventory of a house may be completed either before any XRF testing or on a room-by-room basis during testing.

**1. Number of Room Equivalents to Inspect**

Unless it is assumed that all painted surfaces have lead-based paint, all testing combinations in at least seven room equivalents should be tested (all room equivalents may be tested, at the option of the inspector and owner). Five of the seven room equivalents tested should be:

- The room most likely to be a child's bedroom (preferably the bedroom of the youngest child not sleeping in an adult's bedroom);
- The room with a child's likely play area;
- A bathroom;
- A kitchen; and
- The exterior.

The remaining two room equivalents can be selected based on the professional judgment of the inspector. The inspector should select the two remaining room equivalents most likely to contain lead-based paint. All deteriorated paint should also be tested, regardless of its room equivalent.

After testing the minimum seven room equivalents, an inspector should use the results to characterize the remaining untested room equivalents. Ideally, all room equivalents and testing combinations within a unit should be tested. In most cases, however, the results from the seven room equivalents are sufficient to permit a reasonable assessment of the remaining untested room equivalents.

In discussing the number of room equivalents to test with the client, the inspector (or a responsible representative of the inspector's organization) should explain that shortening the inspection may decrease inspection costs, but may increase the chance that painted components without lead-based paint are classified as positive. Such an error would increase operations, maintenance, interim control, and abatement costs.

For varnished, stained, or similar clear-coated floors, measurements in only one room equivalent are permissible if it appears that the floors in the other room equivalents have the same coating.

If lead-based paint is not found in the first seven room equivalents, it is reasonable to conclude that the entire housing unit is free of lead-based paint. The final report must include a final classification (positive, negative, or inconclusive) for all testing combinations in all room equivalents, whether they were individually tested or not. The report must also indicate which room equivalents were actually tested and which were not.

The inventory should list all room equivalents and all testing combinations in those rooms. The final report must include a final determination of the presence or absence of lead-based paint in each testing combination in each room equivalent, regardless of whether readings were actually collected.

**2. Number of Testing Combinations to Inspect**

Each testing combination in each room equivalent selected for testing should be inspected, unless similar building component types (such as windows) are all found to contain lead-based paint in the first four interior room equivalents. In that case, testing of that component type in the remaining room equivalents may be suspended. The inspector can conclude that the similar building component types in the rest of the dwelling unit also contain lead-based paint, *if and only if* the purchaser of inspection services agrees beforehand to the suspension. For example, if an inspector finds that baseboards in the first four room equivalents are all positive, the inspector -- with the owner's permission -- can conclude that all remaining room equivalents in the unit contain positive baseboards.

Because it is highly unlikely that testing combinations *known* to have been replaced after 1978 will contain lead-based paint, they need not be tested. If the age of the testing combination is in doubt, it should be inventoried and tested.

Some testing combinations have multiple parts. For example, a window testing combination could theoretically be broken down into the interior sill (stool), exterior sill, trough, sash, apron, parting bead, stop bead, casing, and so on. Because it is highly unlikely that all these parts will have different painting histories, they should not be considered separate testing combinations. For most windows, it is sufficient to test the following surfaces:

- Apron or interior sill (stool)
- Sash
- Exterior sill or casing

Similarly baseboards capped by a quarter-round of other trim should be tested as a single testing combination, not two. Doors should be tested on both sides; door casings, stops, transoms, and other door parts should be grouped into a single testing combination. Inspectors can regard parts of building components as separate testing combinations if they have reason to believe that part has a separate, unique painting history.

### 3. Painted Furniture

Furniture that "belongs" to the unit (for example, built-in desks or dressers) should be included in the inspection as a testing combination. Furniture owned by the owner should also be included. If the tenant's painted furniture is present, the inspector should recommend that it be tested. The owner and tenant will need to determine which party should pay for this testing. Because the building's owner cannot control lead-based paint on tenant-owned furniture, excluding such furniture from the scope of the inspection services is permissible. Ideally, all painted furniture should be included.

### 4. Building Component Types

If a positive finding of lead-based paint is determined for a building component type in each of the first four room equivalents, further testing of that component type may be suspended in the remaining room equivalents within that dwelling unit. If, however, findings are negative or inconclusive on a given component type after completion of the first four room equivalents, completion of at least three additional room equivalents is needed.

Results of an inspection may be summarized by classifying component types across room equivalents if patterns are supported by the data.

### 5. Substrates

All substrates across all room equivalents should be grouped into one of the six substrate categories (brick, concrete, drywall, metal, plaster, or wood). Substrate correction procedures can be then applied for all building component types with the same substrate. For example, the substrate correction procedure for wooden doors and wooden baseboards can use the same substrate correction value (see Section E below).

## B. Number and Location of XRF Readings

### 1. Number of XRF Readings for Each Testing Combination

XRF testing is required for at least one location per testing combination, except for interior and exterior walls, where three readings should be taken. Previous editions of this chapter stated that three readings for each testing combination were needed to control for spatial variation and other sources of error. Recent analysis of EPA data show a median difference in spatial variation of only 0.1 mg/cm<sup>2</sup> and a change in classification (positive, negative, or inconclusive) occurs less than 5 percent of the time as a result of different test locations on the same testing

combination. Multiple readings on the same testing combination or testing location are, therefore, unnecessary, except for walls.

Because of the large surface areas involved and the likelihood of increased spatial variation, three readings should be taken on interior and exterior walls in each room equivalent. For example, in a room equivalent with four walls, select at least three to measure. Record the measurement for each individual wall measured. Then, calculate the average and record the average as the result for the fourth wall (or simply take a reading for the fourth wall). For exteriors, select three sides and average the readings to obtain a result for all sides of the dwelling.

If the walls do not follow a clear pattern (for example, one is positive and the other two are negative), take a separate reading on the fourth wall.

## 2. Location of XRF Readings

The selection of the test location for a specific testing combination should be such that it is representative of the paint over the areas most likely to be coated with old paint or other coatings. Thus, locations where the paint appears to be thickest should be selected. Locations where paint has worn away or been scraped off should not be selected. Areas over pipes, electrical surfaces, nails, and other possible interferences should also be avoided if possible. All layers of paint should be included and the XRF probe faceplate should be able to lie flat against the surface of the test location.

If no acceptable location for XRF testing exists for a given testing combination, a paint-chip sample should be collected. The sample should include all paint layers and be taken as unobtrusively as possible. Because paint chip sampling is destructive, a single sample may be collected from a wall and used to characterize the other walls in a room equivalent.

## 3. Documentation of Location of XRF Readings

Descriptions of testing combinations should be sufficiently detailed to permit another individual to find them. Current room uses or colors can change and should not be used for identification purposes. A number system, floor plan, sketch or other system may be used to document which testing combinations were tested. One system that could be used is as follows:

### Side identification

Identify perimeter wall sides with letters A, B, C, and D. Side A in multifamily housing is the apartment entry door side. Side A for single-family housing is the street side for the address.

Side B, C, and D are identified clockwise from Side A; thus Wall B is to the left, Wall C is across from Side A, and Side D is to the right of Side A.

Each room equivalent's side identification follows the scheme for the housing unit. Because a room can have two entries, sides should not be allocated based on the entry point. For example, giving a closet a different side allocation because of how the room is entered would make it difficult for another person to make an easy identification, especially if the room had two closets and two entryways.

### Room Equivalent Identification

Room equivalents are identified by a number. Room 1 is always the first room, at the A-D junction at the entryway. Rooms are consecutively numbered clockwise. If multiple closets exist, they are given the side allocation: for example, Room 3, Side C Closet. The exterior is always assigned a separate room equivalent identifier.

## Sides in a Room

Sides in an interior room equivalent follow the overall housing unit side allocation. Therefore, when standing in any four-sided room facing Side C, the room's Side A will always be to the rear, Side B will be to the right, and Side D will be to the left.

## Building Component Identification

Individual building components are first identified by their room number and side allocation (for example, the radiator in Room 1, Side B is easily identified). If multiple similar component types are in a room (for example, three windows), they are differentiated from each other by side allocation. If multiple components are on the same wall side, they are differentiated by being numbered left to right when facing the components. For example, three windows on Wall D are identified as window D1, D2, and D3, left to right. If window D3 is the only old original sash, it is considered as a separate testing combination.

A sketch of the dwelling unit's floor plan is often helpful. Whatever documentation system is used, a description must be included in the final inspection report.

### C. XRF Instrument Reading Time

The recommended time to open an XRF instrument's shutter to obtain a single XRF result for a testing location depends on the specific XRF instrument model and the mode in which the instrument is operating. The *XRF Performance Characteristics Sheet* provides information on this issue.

To ensure that a constant amount of radiation is delivered to the painted surface, the open-shutter time must be increased as the source ages. Almost all commercially available XRF instruments automatically adjust for the age of the source. (Some instruments adjust for source decay in some but not all modes; operators should check with the manufacturers of their instruments to determine whether these differences need to be accommodated.) The following formula should be employed for instruments requiring manual adjustment of the open-shutter time:

$$\text{Open-Shutter Time} = 2^{(\text{Age}/\text{Half-life})} \times \text{Nominal Time}$$

where:

*Age* is the age of the radioactive source, starting from the date the manufacturer says the source had its full radiation strength;

*Half-life* is the time it takes for the radioactive material's activity to decrease to one-half its initial level; and

*Nominal Time* is the recommended nominal number of seconds for open-shutter time, and is obtained from the *XRF Performance Characteristics Sheet*. For example, if the age of the source is equal to its half-life, the open-shutter time should be twice the nominal time. Thus, if the recommended nominal time is 15 seconds, the open-shutter time would be doubled to 30 seconds.

XRFs typically use Cobalt-57 (half life = 270 days) or Cadmium-109 (half life = 464 days).

*XRF Performance Characteristics Sheets* typically report different inconclusive ranges for different open-shutter times. This factor may affect the number of paint-chip samples that must be collected as well as the length of time required for the inspection.

Some XRF devices have different modes of operation with different reading times. Inspectors must use the appropriate inconclusive ranges and other criteria specified on the *XRF Performance Characteristics Sheet* for each XRF model and each mode of operation. For example, inconclusive ranges specified for a 30-second nominal reading cannot be used for a 15-second nominal reading.

#### **D. XRF Calibration Check Readings**

In addition to the manufacturer's recommended warm up and quality control procedures, the XRF operator should take the quality control readings recommended below, unless this duplicates the manufacturer's instructions. Quality control for XRF instruments involves readings to check calibration. Most XRFs cannot be calibrated on-site; actual calibration can be accomplished only in the factory.

##### **1. Frequency and Number of Calibration Checks**

For each XRF instrument, two sets of XRF calibration check readings are recommended at least every 4 hours. The first is a set of three nominal-time XRF calibration check readings to be taken before the inspection begins. The second occurs either after the day's inspection work has been completed, or at least every 4 hours, whichever occurs first. To reduce the amount of data that would be lost if the instrument were to go out of calibration between checks, and/or if the manufacturer recommends more frequent calibration checks, the calibration check can be repeated more frequently than every 4 hours. If the XRF manufacturer recommends more frequent calibration checks, the manufacturer's instructions should be followed. Calibration should also be checked before the XRF is turned off (for example, to replace a battery or before a lunch break) and after it is turned on again. For example, if an inspection of a large house took 6 hours, there would be three calibration checks: one at the beginning of the inspection, another after 4 hours, and a third at the end of the inspection.

If the XRF is not turned off as the inspector travels from one dwelling unit to the next, calibration checks do not need to be done after each dwelling unit is completed. For example, in multifamily housing, calibration checks do not need to be done after each dwelling unit is inspected; once every 4 hours is usually adequate.

##### **2. Calibration Check Standard Materials**

XRF calibration check readings are taken on the Standard Reference Material (SRM) paint film nearest to 1.0 mg/cm<sup>2</sup> developed by the National Institute of Standards and Technology (NIST). These films can be obtained by calling (301) 975-6776 and referencing SRM #2579. The cost as of May 5, 1997, for a set of five films, was \$314, including 2-day delivery. Calibration checks should be taken through the SRM paint film with the film positioned at least 12 inches away from any potential source of lead. NIST SRM film should not be placed on a tool box, suitcase, or surface coated with paint, shellac, or any other coating to take calibration check readings. Rather, the NIST SRM film should be attached to a solid (not plywood) wooden board or other nonmetal rigid substrate such as drywall, or attached directly to the XRF probe. Readings of the SRM should be taken farther than 1 foot from a surface. Alternatively, NIST SRM film can be placed on top of a 1 cubic foot piece of Styrofoam or other lead-free material, as recommended by the manufacturer before taking readings.

##### **3. Recording and Interpreting Calibration Check Readings**

Each time calibration check readings are made, three nominal-time readings (adjusted for the age of the radioactive source) should be taken. The results can be recorded on the "Calibration Check Test Results" form (Form 7.2), a comparable form, or stored in the instrument's memory. The average of the three calibration check readings should be computed and recorded.

Large deviations from the NIST SRM value will alert the inspector to problems in the instrument's performance. If the observed calibration check average is greater than the calibration check tolerance specified on the instrument's

*XRF Performance Characteristics Sheet*, the manufacturer's instructions should be followed to bring the instrument back into calibration. A successful calibration check should be obtained before additional XRF testing is conducted. Readings not bounded by successful calibration checks at the beginning and end of the testing period are deemed unreliable and should be repeated. If a backup XRF instrument is used as a replacement, it must successfully pass the initial calibration check test before retesting the affected test locations.

This procedure assumes that the HUD standard of 1.0 mg/cm<sup>2</sup> is being used. If a different standard is being used, other NIST SRMs should be used to determine instrument performance in the region of interest.

#### **E. Substrate Correction**

XRF readings are sometimes subject to systematic biases as a result of interference from substrate material beneath the paint. The magnitude and direction of bias depends on the substrate, the specific XRF instrument being used, and other factors such as temperature and humidity. Results can be biased in either the positive or negative direction and may be quite high.

##### **1. When Substrate Correction Is Not Required**

Some XRF instruments do not need to have their readings corrected for substrate bias. Other instruments may only need to apply substrate correction procedures on specific substrates and/or when XRF results are below a specific value. The *XRF Performance Characteristics Sheet* should be consulted to determine the requirements for a specific instrument and each mode of operation.

##### **2. Substrate Correction Procedure**

XRF results are corrected for substrate bias by subtracting a correction value determined separately in each house for each type of substrate where lead paint values are in the substrate correction range indicated on the *XRF Performance Characteristics Sheet*. In single-family housing, the substrate correction value is determined using the specific instrument(s) used in that house. The correction value (formerly called "Substrate Equivalent Lead" or "SEL") is an average of XRF readings taken from test locations that have been scraped visually clean of their paint coating. The location selected for removal of paint should have an initial XRF reading on the painted surface of less than 2.5 mg/cm<sup>2</sup>, if possible. If all initial readings on a substrate type are greater than 2.5 mg/cm<sup>2</sup>, the locations with the lowest initial reading should be chosen. This approach will help ensure that XRF readings taken from non-representative portions of substrates and other underlying materials, such as hidden nails and pipes, are not used to compute the substrate correction.

After all XRF testing has been completed but before the final calibration check test has been conducted, XRF results for each substrate type should be reviewed. If any fall within the range for substrate correction for a particular substrate, do so. If none of the results are within that range, however, no substrate correction is required.

On each selected testing combination, one location must be chosen for paint removal. Two different testing combinations must be chosen for each substrate type that requires correction. For example, if the readings are inconclusive for some wooden baseboards, select two baseboards, each from a different room. If some wooden doors also require substrate correction, the inspector should take substrate correction readings on one door and one baseboard. Selecting the precise location of substrate correction should be based on the inspector's ability to remove paint thoroughly from the substrates, the similarity of the substrates, and accessibility.

In all, six readings must be taken for each substrate type that requires correction. All six must be averaged together. The XRF probe faceplate must be able to be placed over the scraped area, which should be completely free of all paint or other coatings.

The size of the area from which paint is taken depends on the size of the analytical area of the XRF probe faceplate; normally, area size is specified by the manufacturer. To ensure that no paint is included in the bare substrate measurement, the bare area on the substrate should be slightly larger than the analytical area on the XRF probe faceplate.

Take three readings on the first *bare* substrate area. Record the substrate and XRF readings on the "Substrate Correction Values" form (Form 7.3) or a comparable form. Repeat this procedure for the second *bare* substrate area and record the three readings on the same form. Substrate correction values should be determined using the same instrument used to take readings on the painted surfaces. If more than one XRF model was used to take readings, apply the substrate correction values as specified on each instrument's *XRF Performance Characteristics Sheet*.

- Compute the correction value for each substrate type that requires correction by computing the average of all six readings as shown below and recording the results on the "Substrate Correction Values" form. The formula given below should be used to compute the substrate bias correction value for XRF readings taken on bare substrate that is not covered with NIST SRM film. A different formula should be used when SRM film must be placed over the bare substrate. The *XRF Performance Characteristics Sheet* specifies when this correction is necessary and provides the appropriate formula for computing the correction value.

For each substrate type requiring substrate correction:

- Transfer the recorded correction values to the "Single-Family Housing LBP Testing Data Sheet" (Form 7.1) for each corresponding substrate. Correct XRF readings for substrate interference by subtracting the correction value from each XRF reading.

*Example:*

Suppose that a house has 50 testing combinations with wood substrates. The *XRF Performance Characteristics Sheet* states that a correction value for XRF results taken on those wood testing combinations that have values less than 4 mg/cm<sup>2</sup> must be computed. Randomly select two test locations from the testing combinations that had uncorrected XRF results of less than 2.5 mg/cm<sup>2</sup>. Remove the paint from these two test locations and take three nominal-time XRF readings on the bare substrate at each location. Suppose the six XRF readings at the two random locations are:

Selected Location	Reading (mg/cm <sup>2</sup> )		
	First	Second	Third
First	1.32	0.91	1.14
Second	1.21	1.03	1.43

The correction value is the average of the six values:

$$\text{Correction value} = (1.32 + 0.91 + 1.14 + 1.21 + 1.03 + 1.43) / 6 = 1.17$$

In this same house, suppose that three different wood testing combinations were inspected for lead-based paint and the XRF results are: 1.63, 3.19, and 1.14. Correcting these three XRF measurements for substrate bias produces the following results:

$$\text{First corrected measurement} = 1.63 - 1.17 = 0.46$$

$$\text{Second corrected measurement} = 3.19 - 1.17 = 2.02$$

$$\text{Third corrected measurement} = 1.14 - 1.17 = -0.03$$

The third corrected result shown above is an example of how random error in XRF measurements can cause the corrected result to be less than zero. (Random measurement error is present whenever any quantitative measurements are taken.) Note that correction values can be either positive or negative. In short, negative corrected XRF values are permissible if supported by the data.

Finally, suppose an XRF result of 1.24 mg/cm<sup>2</sup> and a correction value of negative 0.41 mg/cm<sup>2</sup>. Subtracting a negative number is the same as adding its positive value. Therefore, the corrected measurement would be:

$$\text{Corrected result} = 1.24 - (-0.41) = 1.24 + 0.41 = 1.65$$

### 3. Negative Values

If more than 20 percent of the corrected values are negative, the instrument's lead paint readings and/or the substrate readings are probably in error. Calibration should be checked and repeated substrate measurements should be repeated.

#### F. Discarding Readings

If the manufacturer's instructions call for the deletion of readings at specific times, only readings taken at those specific times should be deleted. Similarly, readings between a successful calibration and a subsequent unsuccessful calibration must be discarded. Readings should not be deleted based on any criteria other than what is specified by the manufacturer's instructions or the *HUD Guidelines*. For example, some manufacturers instruct operators to discard the first XRF reading after a substrate change. If this instruction is applicable, only the *first* reading should be discarded after substrate change.

#### G. Classification of XRF Results

XRF results are classified as positive, negative, or inconclusive.

A *positive* classification indicates that lead is present on the testing combination at or above the HUD standard of 1 mg/cm<sup>2</sup>. A positive XRF result is any value greater than the upper bound of the inconclusive range specified on the performance characteristics sheet.

A *negative* classification indicates that lead is not present on the testing combination at or above the HUD standard. A negative XRF result is any value less than the lower bound of the inconclusive range specified on the performance characteristics sheet.

An *inconclusive* classification indicates that the XRF cannot determine with reasonable certainty whether lead is present on the testing combination at or above the HUD standard. An inconclusive XRF result is any value falling within the inconclusive range on the performance characteristics sheet (including the boundary values defining the

range). In single-family housing, all inconclusive results should be confirmed by laboratory analysis, unless the owner wishes to assume that all inconclusive results are positive.

Positive, negative, and inconclusive results apply to the actual testing combination, to any repetitions of the testing combination in the room equivalents that were not tested, and to similar component types in room equivalents that were not tested. For example, suppose that four walls comprise a testing combination and that XRF readings were taken at test locations on three of the walls. Although the resulting classification is based on XRF results from the three tested walls, it also applies to the untested fourth wall. Similarly, if only one baseboard is tested, the result applies to all four baseboards (if the inspector concludes that all four baseboards are a single testing combination).

XRF results are classified as positive if they are greater than -- and negative if they are less than --inconclusive range specified on the *XRF Performance Characteristics Sheet*. Otherwise, they are classified as inconclusive. (The inconclusive range on the *XRF Performance Characteristics Sheet* includes its upper and lower bounds.) Earlier editions of this guide and performance characteristics sheets did not include the bounds of the inconclusive range as "inconclusive." This guide changes that system, but the specific positive, negative, and inconclusive ranges for a given XRF model remain unchanged.

For example, if the inconclusive range given in the *XRF Performance Characteristics Sheet* is 0.51 to 1.49 mg/cm<sup>2</sup>, an XRF result of 0.50 mg/cm<sup>2</sup> would be negative, because it is less than 0.51; a result of 0.6 mg/cm<sup>2</sup> would be inconclusive; and a result of 1.5 mg/cm<sup>2</sup> would be positive. A result of 0.51 or 1.49 mg/cm<sup>2</sup> would be inconclusive.

Different XRF models have different inconclusive ranges. Depending on the specific XRF model and mode of operation, the inconclusive range may or may not be substrate-specific. For some XRF models, upper and lower limits may be equal; their value is called the *threshold*. Use of the inconclusive range and threshold is detailed in the performance characteristics sheet. The categories apply to substrate-corrected results, if substrate correction is indicated.

## H. Evaluation of the Quality of the Inspection

The person responsible for purchasing inspection services -- the homeowner, property owner, housing authority, prospective buyer, occupant, etc. -- should evaluate the quality of the work using one or more of the methods listed below. Evaluation methods include direct observation, immediate provision of results, repeated testing, and time-and-motion analysis. Direct observation of the inspection should be used whenever possible. The inspection contract should outline the financial penalties that will occur if an inspector fails to perform as contracted during any visit.

### 1. Direct Observation

An evaluation of a lead-based paint inspection is best made if an observer is present for as much of the XRF testing as possible. This is the only way to ensure that all painted, varnished, shellacked, wallpapered, stained, or other coated surfaces are inventoried and that all XRF readings are recorded correctly. It is advisable to employ as the observer someone who is trained in lead-based paint inspection and who is independent of the inspection firm.

If it is not feasible for the owner or the owner's representative to be present throughout the inspection, that person should conduct unannounced visits to observe the inspection process. The number of unannounced visits will depend on the results of prior visits. When observing ongoing XRF testing, review the test results for the room equivalent currently being tested and for the previously inspected room equivalent. Even if the first visit is fully satisfactory, periodic visits should be conducted periodically throughout the inspection.

### 2. Immediate Provision of Results

Ask the inspector to provide copies or printouts of results on completed data forms immediately following the completion of the inspection or on a daily basis. Alternatively, visually review the inspector's written results to ensure that they are properly recorded for all surfaces that require XRF testing. If a surfaces have been overlooked or recorded incorrectly, the inspection process should be stopped and considered deficient. Owners should retain daily results to ensure that the data in the final report are the same as the data collected in the house.

### **3. Repeated Testing of 10 Surfaces**

Data from HUD's private housing lead-based paint hazard control program show that it is possible to successfully retest painted surfaces without knowing their exact location.

Select 10 testing combinations at random from the already compiled list in the "Single-Family Housing LBP Testing Data Sheet" for retesting (see forms at the end of this chapter). Observe the inspector during the retesting. If possible, the XRF instrument used in the original inspection should be used in the retesting. Use the same procedures to retest the 10 testing combinations. The 10 repeat XRF results should be compared with the 10 XRF results previously made on the same testing combinations. Neither the repeat readings nor the original readings should be corrected for substrate bias. The average of the 10 repeat XRF results should not differ from the 10 original XRF results by more than the retest tolerance limit. The procedure for calculating the retest tolerance limit is specified in the *XRF Performance Characteristics Sheet*. If the limit is exceeded, the procedure should be repeated using 10 different testing combinations. If the retest tolerance limit is exceeded again, the original inspection is considered deficient.

### **4. Time-and-Motion Analysis**

Anyone who contracts for a lead-based paint inspection can also perform a simple check to determine if the inspector had sufficient time to complete the number of housing units reported tested in the time allotted. Usually, inspections require at least 1 to 2 hours per unit using existing technology. If the inspector's on-site time is significantly less than that, further investigation should be conducted to determine if the inspector actually completed the work in the report.

## **I. Documentation in Single-Family Housing**

### **1. Data Forms**

Data can be recorded on hand written forms, electronically, or by a combination of these two methods. XRF readings can be entered on handwritten forms, such as the set of forms provided at the end of this chapter (or comparable forms). Because handwriting can result in transcription errors, handwritten forms should be examined for missing data and copying errors.

### **2. Electronic Data Storage**

Electronic data storage is recommended only if the data recorded are sufficient to allow another person to find the testing combination that corresponds to each XRF reading. Electronically stored data should be printed in hard copy either daily or at the completion of the inspection. The printout should be examined for extraneous symbols or missing data, including missing test location identification.

### **3. Final Report**

The final report must include both a summary and complete information about the site, the inspector, the inspection firm, inspection process, and inspection results. The full report should include a complete data set, including:

- Housing unit identifiers;
- Date of the inspection;
- Identity of the inspector and the inspection firm and any relevant certifications or licenses held by the inspector and/or the firm;
- Building component and room equivalent identification or numbering system or sketches;
- All XRF readings (including calibration check readings);
- All paint chip analyses;
- Testing protocol used;
- Instrument manufacturer, model, serial number, mode(s) of operation and age of radioactive source;
- Final classification of all painted or coated building components in each room equivalent into positive, negative, or inconclusive categories (including a list of surfaces and room equivalents that were classified but not individually tested); and
- Information on the owner's legal obligation to disclose the inspection results to tenants and/or purchasers before obligation under 24 CFR Part 35 and 40 CFR Part 745 (published in the *Federal Register*, Volume 61, Number 45, March 6, 1996, starting on p.9064).

The summary report should answer two questions: (1) Is there lead-based paint in the house? And (2) if lead-based paint is present, where is it located? The summary report should also include the house address where the inspection was performed, the date(s) of the inspection, the name, address and phone number of the inspector or inspection firm, and any appropriate license or certification number, and the starting and ending times for each day when XRF testing was done. The summary should also contain the following language regarding disclosure:

"A copy of this summary must be provided to new lessees (tenants) and purchasers of this property under Federal law (24 CFR Part 35) before they become obligated under a lease or sales contract. The complete report must also be provided to new purchasers and it must be made available to new tenants. Landlords (lessors) and sellers are also required to distribute an educational pamphlet and include standard warning language in their leases or sales contracts to ensure that parents have the information they need to protect their children from lead-based paint hazards. This report will be kept by the inspector and should also be kept by the owner and should be passed on to all future owners."

If no lead-based paint has been detected in the house, the summary should say so. The following language may be used:

"The results of this inspection indicate that no lead in concentrations greater than or equal to 1 mg/cm<sup>2</sup> in paint was found on any building components, using the inspection protocol in Chapter 7 of the *HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*. Therefore, this dwelling qualifies for the exemption in 24 CFR Part 35 for target housing being leased that is free of lead-based paint. However, some painted surfaces may contain levels of lead below 1 mg/cm<sup>2</sup>, which could create lead dust or lead-contaminated soil hazards if the paint is turned into dust by abrasion, scraping, or sanding. This report will be kept by the inspector and should also be kept by the owner and should be passed on to all future owners."

1 Detailed documentation of the XRF testing should also be provided in the full report, including the raw data upon  
2 which it was based. The single-family housing forms provided at the end of this chapter or comparable forms would  
3 serve this purpose.  
4  
5

6 **V. Inspections in Multifamily Housing**  
7

8 This section emphasizes the differences between single-family and multifamily housing paint inspections. The  
9 protocols mentioned in earlier sections are not repeated here. It will be necessary to read Section IV on single-family  
10 housing to implement the protocol for multifamily housing.  
11

12 For purposes of this chapter only, multifamily housing is defined as any group of 16 or more units that are similar in  
13 construction from unit to unit. Developments with 15 or fewer units should be treated as single-family housing.  
14

15 Use of the multifamily protocol is less time-consuming and more cost effective than inspecting all units in a given  
16 housing development or building because in most instances a pattern can be determined after inspecting a fraction of  
17 the units. The number of units tested is based on the date of construction and the number of units in the housing  
18 development.  
19

20 **A. Statistical Confidence in Dwelling Unit Sampling**  
21

22 The number of units to be tested (the sample size) is based on the total number of units in the building(s), as specified  
23 in Table 7.3. If lead levels in *all* units tested are found to be at or below the 1.0 mg/cm<sup>2</sup> standard, these sample  
24 sizes provide 95 percent confidence that less than 5 percent of pre-1960 housing units and 10 percent of buildings  
25 constructed from 1960 to 1977 have lead at or above the standard.

Table 7.3 Number of Units to be Tested in Multifamily Developments

[Note for review: The final table will be expanded to include building/development size ranges for all numbers of units to be sampled for buildings/developments of up to 1,040 units.]

Number of Units in Building or Development	Number of Units to Test in Pre-1960 (Includes Those with Unknown Age)	Number of Units to Test in 1960-1977 Building or Development
< 16	All	All
20	All	16
40	31	21
60	38	23
80	42	24
100	45	25
200	51	27
300	54	28
400	55	28
600	56	28
1000	57	29
1500	87	43
2000	116	58
2500	145	73
3000	174	88
3500	203	102
4000	232	117

Although the data set used to develop sample sizes in multifamily housing<sup>2</sup> was not randomly selected from all multifamily housing developments in the nation (no such data set is available), analyses drawn from the data are likely to err on the side of safety and public health for at least two reasons: First, the prevalence and concentrations of lead-based paint are highest in pre-1960 housing developments. The sampling approach used here focuses inspection efforts on buildings where a greater chance of lead-based paint hazards exists.

Second, and perhaps more important, none of the 65 developments had lead-based paint in 5 to 10 percent of the units. That indicates lead-based paint in this range is likely to be quite rare and that plausible increases in sampling to improve detection in this range will fail to improve the results significantly. Most painting follows a pattern: Property owners or managers often paint all surfaces, all components within a room, or similar components in all rooms in a unit when there is a tenant turnover. It is unlikely that lead-based paint distributions are completely

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<sup>1</sup> The statistical rationale and calculations used to develop sample sizes in multifamily housing, as well as a description of the large set of empirical data assembled by HUD, will be presented in Revised Appendix 12. The data set contains approximately 164,000 XRF readings from 23,000 room equivalents in 3,900 units located in 65 housing developments. Statistical and theoretical analyses completed for HUD are available through the Lead Clearinghouse and on HUD's World Wide Web Home Page

random, as assumed in the June 1995 edition of the *Guidelines* (which sampled for 95 percent confidence that fewer than 5 percent of units in all pre-1978 buildings have lead-based paint). It is reasonable to follow the indication of the available data that either very few or many units in a development have lead-based paint. From the available data, there appears to be no overall benefit to increasing the number of units to be sampled to detect a prevalence rate of 5 to 10 percent, because few developments are likely to be in that range.

Use of the empirical data enables a more targeted cost-effective approach. For pre-1960 or unknown-age buildings or developments with 1,040 or more units, test 5.8 percent of the units, and round up any fraction to the next whole number. For 1960-78 buildings or developments with 1,000 or more units, test 2.9 percent of the units, and round up any fraction to the next whole number.

## **B. Selection of Housing Units**

The first step in selecting housing units is to identify buildings in the development with a common construction based on written documentation or visual evidence of construction type. Such buildings can be grouped together for sampling purposes. For example, if two buildings in the development were built at the same time by the same builder and appear to be of similar construction, all of the units in the two buildings can be grouped for sampling purposes. Units can have different sizes, floor plans, and number of bedrooms and still be grouped.

The specific units to be tested should be chosen *randomly* from a list of all units in each building or buildings. The "Selection of Units" form (Form 7.4) or a comparable form may be used to aid in the selection process. A complete list of all units in each group should be used and a separate identifying sequential number must be assigned to each unit. For example, if apartment addresses are shown as 1A, 1B, 2A, 2B etc., they must be given a sequence number (1, 2, 3, 4, etc.).

Obviously, units without identifiers could not be selected for inspection and would thus bias the sampling scheme. The list of units should be complete and verified by consulting building plans or by a physical inspection of the development.

Specific units to be tested should be selected randomly using the formula below and a table of random numbers or the random number function on a calculator. Tables of random numbers are often included in statistics books. Calculators with a random number function key can be obtained for less than \$20 and are easier to use than tables, inspectors are, therefore, advised to use them to obtain the random numbers, which can then be used to select the specific numbered units. A unit number is selected by rounding up the product of the random number times the total number of units in the development. That is,

$$\text{Housing Unit number} = \text{Random number} \times \text{Total number},$$

where:

Housing Unit number = the identification number for a unit in a list;

Random number = a random number between 0 and 1; and

Total number = the total number of units in a list of units.

The same unit may be selected more than once by this procedure. Because each unit one should be tested only once, duplicate selection should be documented and then discarded. The procedure should be continued until an adequate number of units has been selected.

The "Selection of Units" form (Form 7.4) is completed by filling in as many random numbers as are needed in the appropriate column. Numbers for the third column are obtained by multiplying the total development size by each random number. Numbers for the fourth column are obtained by rounding up from the previous calculation. If the value for the fourth column has already been selected, that selection should not be numbered. The notation "DUP" should be entered to indicate that the selection was a duplicate. This process should continue until the required number of distinct sample numbers have been selected. Common areas and exterior room equivalents should be identified at this time, but they are not considered to be separate units.

### **C. Inventory and Selection of Painted Surfaces**

The "Multifamily Housing LBP Testing Data Sheet" form (Form 7.5) -- or comparable form -- should be used to carry out the inventory of painted surfaces in each unit and each common area that was selected for inspection. In multifamily housing, the inventory of testing combinations often will be similar for units that have the same number of bedrooms. The inspector should, however, list testing combinations that are unique to each tested unit. For example, some units may contain built-in cabinets while others do not. The selection of testing combinations should, therefore, be carried out independently in each inspected unit.

All room equivalents, whether they are interior rooms, common areas, or exterior surfaces or areas, must be included in the inventory of the housing. Inspectors may find master plans for the housing development useful in performing this inventory.

#### **1. Common Areas**

In multifamily housing, each common area (such as a building lobby, laundry room, or hallway) is considered to be a room equivalent (but not a dwelling unit) for inventory purposes. Common areas must always be tested. Common areas and building exteriors typically have a similar painting history from one building to the next. If maintenance records or visual evidence supports this, at least 10 similar common areas and 10 similar building exteriors within a given building or housing development should be tested.

All testing combinations within each common area or on building exteriors selected for testing must be inspected. The specific common areas and building exteriors to test should be randomly selected, in much the same way as specific units are selected using random numbers. (See Section B above.)

If test results do not show a pattern, the number of common areas to test should be taken from Table 7.3. In this instance, common areas and building exteriors can be considered to be special housing units (not to be confused with true housing units within the building(s)).

### **D. Number of Readings on Each Testing Combination**

Methods for collecting XRF readings are identical for multifamily and single-family housing.

### **E. XRF Calibration Check Readings**

XRF calibration check readings should be collected in the same manner as described for single-family housing (see Section IV).

## **F. Substrate Correction in Multifamily Housing**

The method for correcting XRF readings for substrate bias should be performed as described for single-family housing with one exception: Randomly select two housing units to be used to collect substrate measurements for all substrates within the development that need correction. Results from those two units can be used to perform substrate correction calculations in all tested units within the development or building.

## **G. Classification of XRF Results in Multifamily Housing**

The inspector should record each XRF reading for each testing combination on the "Multifamily Housing LBP Testing Data Sheet," (Form 7.5) or a comparable form, and indicate whether that testing combination was classified as positive, negative, or inconclusive as described previously for single-family housing.

When the inspection is completed in all of the selected units and the classification rules have been applied to all XRF results, the "Multifamily Housing: Component Type Report" form (Form 7.6) or a comparable form should be completed. Building component types -- groups of like components constructed of the same substrate in the multifamily housing development -- are aggregated on this form. For example, grouping all interior walls would create an appropriate component type if all walls are plaster. Grouping all doors would not be appropriate, however, if some doors are metal and some are wood. At least 40 testing combinations of a given component type in a multifamily housing development must be tested to obtain the desired level of confidence in the results. (Refer to Appendix 12 for the statistical rationale for this minimum number of component types to test.) If fewer than 40 testing combinations of a given component type were tested, additional components will need to be tested. If less than 40 components of a given type exist in the units to be tested, further XRF testing is not necessary.

In some cases additional sampling of the specific component may not be necessary. If no lead at or above the standard is found on that component type, additional measurements should be taken in other units to increase the sample size to 40. However, if all or most of the sampled component types are positive, no further sampling is needed. For example, if 20 out of 60 doors are tested, and the majority have lead levels of 1.0 mg/cm<sup>2</sup> or greater, it may be presumed that all similar doors in the buildings are positive. The converse does not apply. All required XRF testing must be completed to conclude that all components included in a given component type are negative.

On the "Multifamily Housing: Component Type Report" form, the substrate, and component for each component type should be recorded under the heading "Description" (for example, wooden doors) as well as the total number of testing combinations included in the component type. In addition, for each component type, the aggregated positive, negative, and inconclusive classifications should be recorded as described below. Record the number and percentage of testing combinations classified as:

- *Positive relative to the HUD standard of 1.0 mg/cm<sup>2</sup>;*
- *Inconclusive and having XRF readings of less than 1.0 mg/cm<sup>2</sup>;*
- *Inconclusive and having XRF readings equal to or greater than 1.0 mg/cm<sup>2</sup>; and*
- *Negative.*

*Percentages are computed by dividing the number in each classification group by the total number of testing combinations of the component type that were tested. For example, if 245 wooden doors in a multifamily housing development were tested and 69 were classified as inconclusive with XRF readings less than 1.0 mg/cm<sup>2</sup>, 28 percent [(69 / 245) x 100 percent = 28.2 percent] should be recorded on the form in the "< 1.0 mg/cm<sup>2</sup> percent" columns under the heading "Inconclusive."*

The "Multifamily Decision Flowchart" (Figure 7.11) should be used to interpret the aggregated XRF testing results in the "Multifamily Housing: Component Type Report" form. The flowchart is applied separately to each component type (doors, window casings, etc.) and indicates one of the following results:

- **Positive:** Lead is present on one or more of the components at or above the HUD standard of 1.0 mg/cm<sup>2</sup>.
- **Negative:** Lead is not present on any of the components at or above the HUD standard of 1.0 mg/cm<sup>2</sup>. (Lead may still be present and hazardous lead dust may be generated during modernization, renovation, remodeling, maintenance, or other disturbances of painted surfaces.)

These results are obtained by following the flowchart. The decision that lead-based paint is present is reached with 99 percent confidence if 15 percent or more of the components are positive. (Refer to Revised Appendix 12 for the statistical rationale for this percentage.) The decision that no lead is present is reached if: (1) 100 percent of the tested component types are negative, or (2) 100 percent of the tested component types are classified as either negative or inconclusive and all of the inconclusive classifications have XRF readings of less than 1.0 mg/cm<sup>2</sup>. For all other cases, some confirmatory laboratory testing is needed to reach a final conclusion, unless the owner wishes to assume all inconclusives are positive, or unless additional units are selected for further testing (see the section on "unsampled units," below). For each testing combination with an inconclusive XRF reading of 1.0 mg/cm<sup>2</sup> or greater, a paint-chip sample should be analyzed by a laboratory recognized by the EPA National Lead Laboratory Accreditation Program. If all these samples are negative, it is not necessary to test inconclusive XRF results below 1 mg/cm<sup>2</sup>. If, however, any laboratory results are positive on a component type, all inconclusives below 1 mg/cm<sup>2</sup> must be analyzed. Once all laboratory results have been reported, the "Multifamily Housing: Component Type Report" form should be updated to include the laboratory results and classifications (either positive or negative).

Percentages used in the "Multifamily Decision Flowchart" are based on data collected by EPA in a large field study of XRF instruments.<sup>3</sup> Percentages were chosen so that, for each component type, there is a 98 percent chance of correctly concluding that lead-based paint is either absent on all components or present on at least one component of a given type. Thus, the probability that a tested component type will be correctly classified is very high.

### 1. Unsamped Housing Units

If a particular component type in the sampled units is classified as positive, that same component type in the unsampled units is also positive. For those cases where the number of positive components is small, further analysis may determine if there is a systematic reason for the specific mixture of positive and negative results.

For example, suppose that a few porch railings tested negative, but most tested positive. Examination of the sample results in conjunction with the building records showed that the porch railings classified as positive were all original and the railings classified as negative were all recent replacements. The records did not reveal which units had replaced railings, and due to historic preservation requirements, the replacement railings were identical in appearance to the old railings. Thus, all unsampled original porch railings could be classified as positive, and all unsampled recently replaced porch railings could be classified as negative if at least 40 of the replaced porch railings had been tested.

### 2. Fewer than 5% Positive Results

For cases where 5 percent or less of a particular component type are positive, the purchaser of the inspection services may choose to have a second random sample selected, particularly if building records are not useful. Use the same random selection procedure when identifying units for the second sample. The same number of units should be selected as for the first sample, and selections should only be taken from the list of unsampled units.

1 If the combination of the two random samples for a particular component type results in fewer than 2.5 percent  
2 positive classifications, the owner may bring testing to a conclusion to avoid continuing to expend resources on  
3 difficult-to-find components coated with lead-based paint. The inspector may conclude that the development does not  
4 contain other development-wide components with lead-based paint in unsampled units with a reasonable degree of  
5 confidence. Individual components in the samples that were classified as positive should be managed or abated  
6 appropriately.

7  
8 If the two samples combined have 2.5 percent or more components of a given type that are classified as positive,  
9 further testing of all components of that type, or further investigation of building records in conjunction with the two  
10 sample results, or both, is required to determine where the lead-based paint is located. Alternatively, all of the  
11 components of that type may be presumed to be positive for lead-based paint (except for those which tested negative).  
12

13 Whatever approaches are used, all painted surfaces found to be positive for lead relative to the HUD standard must  
14 be included in the inspection report.  
15

#### 16 **H. Evaluation of the Inspection**

17  
18 Options for evaluating inspection services in multifamily housing are identical to those described for single-family  
19 housing except for the retesting option. In multifamily housing, a total of 10 testing combinations should be selected  
20 for retesting in two units.  
21

#### 22 **I. Documentation in Multifamily Housing**

23  
24 Documentation of a multifamily housing inspection should be done as described for single-family housing, with the  
25 following exception: Use forms for multifamily housing (found at the end of this chapter) or comparable forms, not  
26 the single-family housing forms.  
27

### 28 **VI. Laboratory Testing for Lead in Paint**

29  
30 For inconclusive XRF results and areas that cannot be tested using an XRF instrument, a paint-chip sample should be  
31 collected using the protocol outlined here and in Appendix 13.2. The sample should be analyzed by a laboratory  
32 recognized under the EPA National Lead Laboratory Accreditation Program using the analytical method it used under  
33 its accreditation.  
34

#### 35 **A. Number of Samples**

36  
37 Only one paint-chip needs to be taken for each testing combination. Additional samples can be collected as a quality  
38 control measure, if desired.  
39

#### 40 **B. Size of Samples**

41  
42 The paint-chip sample should be taken from a 4-square-inch (25-square-centimeter) area that is representative of the  
43 paint on the testing combination, as close as possible to any XRF reading, and is unobtrusive. This area may be a 2  
44 by 2 inch (5 by 5 centimeter) square, or a 1 by 4 inch (2.5 by 10 centimeter) rectangle, or have any other dimensions  
45 that equal 4 square inches (25 square centimeters). Regardless of shape, the dimensions of the surface area must be  
46

accurately measured (to the nearest millimeter or 1/16th of an inch) so that laboratory results can be reported in mg/cm<sup>2</sup>. Results should be reported as percent by weight if the dimensions of the surface area cannot be accurately measured or if all paint within the sampled area cannot be removed. In these cases, lead should be reported in ppm or percent by weight, not in mg/cm<sup>2</sup>. Smaller surface areas can be used if acceptable to the laboratory.

The 4-square-inch (25-square-centimeter) area practically guarantees that a sufficient amount of paint will be collected for laboratory analysis. As a result, samples will sometimes weigh more than required for some laboratory analysis methods. In such cases, homogenization and subsampling in the laboratory may be necessary before analysis. Smaller-sized paint chips may be collected if permitted by the laboratory. (See ASTM E 1728.)

#### C. Inclusion of Substrate Material

Inclusion of substrate material in the paint-chip sample will result in minimal error if results are reported in mg/cm<sup>2</sup>. However, substrate material cannot be included if results are reported in weight percent (or ppm).

#### D. Repair of Sampled Locations

Areas from which paint-chip samples are collected should be repaired and cleaned, unless the area will be removed, encapsulated, enclosed, or repainted before occupancy. Repairs can be completed by repainting, spackling, or any other method of covering that renders the bare surface inaccessible. Cleanup should be done with wet wiping and rinsing, and it should be done on both the surface and the floor underneath the surface sampled. The new covering or coating should have the same expected longevity as new paint or primer. Repair is not necessary if analysis shows that lead content is below the HUD standard of 1 mg/cm<sup>2</sup>.

#### E. Classification of Paint-Chip Sample Results

All paint inspections may be carried out using paint-chip sampling and laboratory analysis at the option of the purchaser of the inspection services. This option is not recommended because it is time consuming, costly, and requires extensive repairs. Paint-chip sampling also has many opportunities for errors, such as inclusion of substrate material (for results in weight percent), failure to remove all paint from an area (including paint that has bled into a substrate) and laboratory error. Nevertheless, paint-chip sampling generally has a smaller error than does XRF and is, therefore, appropriate as a final decisionmaking tool. Laboratory results of  $\geq 1.0$  mg/cm<sup>2</sup> or greater (or 0.5 percent or greater) are to be considered positive. If the laboratory reports both mg/cm<sup>2</sup> and weight percent for the same sample, use whichever result is positive (if any) for final classification. In an unusual situation where more than one paint-chip sample from a single testing combination is analyzed, the combination is considered positive if any of those samples is positive. All other results are negative. No inconclusive range is reported for laboratory measurements.

#### F. Units of Measure

Results should be reported in mg/cm<sup>2</sup>, the primary unit of measure for lead-based paint analyses. Results should be reported as percent by weight only if the dimensions of the surface area cannot be accurately measured or if all paint within the sampled area cannot be removed. In these cases, results should not be reported in mg/cm<sup>2</sup>, but in weight percent.

Weight measurements are usually reported as micrograms per gram ( $\mu\text{g/g}$ ), milligrams per kilogram ( $\text{mg/kg}$ ), or parts per million (ppm) by weight. For example, a sample with 0.2 percent lead may be reported as 2,000  $\mu\text{g/g}$  lead, 2,000  $\text{mg/kg}$  lead, or 2,000 ppm lead.

#### G. Sample Containers

Samples should be collected in sealable rigid containers such as screw-top, plastic centrifuge tubes, rather than plastic bags which generate static electricity and make quantitative transfer of the entire paint sample in the laboratory impossible. Paint-chip collection should include collection of all the paint layers from the substrate. Collection of actual substrate should be minimized. If substantial substrate material is included, results should be reported in  $\text{mg/cm}^2$  to avoid a downward bias in results. Refer to ASTM E 1728 and Appendix 13 for further details on collection of paint-chip samples.

#### H. Laboratory Analysis Methods

Several standard laboratory technologies are useful in quantifying lead levels in paint-chip samples. These methods include, but are not limited to, Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES).

For analytical methods that require sample digestion, samples should be pulverized so that there is adequate surface area to dissolve the sample before laboratory instrument measurement. In some cases, the amount of paint collected from a 4-square-inch area may exceed the amount of paint that can be analyzed successfully. It is important that the actual sample mass analyzed not exceed the maximum mass the laboratory has successfully tested using the specified method. If subsampling is required to meet analytical method specifications, the laboratory must homogenize the paint-chip sample (unless the entire sample will eventually be analyzed and the results of the subsamples combined). Without homogenization, subsampling would likely result in biased, inaccurate lead results (see ASTM E 1645).

If the sample is properly homogenized and substrate inclusion is negligible, the result can be reported in either milligrams per square centimeter ( $\text{mg/cm}^2$ ), percent by weight, or both. The following equation should be used to report the results in milligrams per square centimeter:

$$\text{mg/cm}^2 = \frac{\text{weight of lead from subsample (in mg)}}{\text{subsample weight (in g)}} \times \frac{\text{total sample weight (in g)}}{\text{subsample weight (in g)}}$$

---

sample area (in  $\text{cm}^2$ )

To report results in weight percent, the following equation should be used:

$$\text{Weight percent} = \text{weight of lead/weight of subsample} \times 100.$$

To report results in micrograms per gram ( $\mu\text{g/g}$ ), the following equation should be used:

$$\mu\text{g/g} = \frac{\text{weight of lead from subsample (in } \mu\text{g})}{\text{subsample weight (in g)}}$$

If the laboratory report results in both mg/cm<sup>2</sup> and weight percent, and if one result is positive and the other negative, the positive result should be used to classify the sample.

Whatever the preparation techniques of paint-chip samples (including homogenization, grinding, and digestion), the laboratory should demonstrate successful use of the method before undertaking analysis of any field samples. Methods should be applied to paint-chip materials of approximately the same mass and lead loading (also called area concentration, measured in mg/cm<sup>2</sup>) as those samples anticipated from the field.

Because of the potential for sample mass to affect lead readings, reference materials processed with field samples for calibration check should be close to the same mass as those used for paint-chip samples. Refer to ASTM E 1645 or equivalent methods for further details on laboratory preparation of paint-chip samples, and refer to ASTM E 1613 or equivalent methods on analysis of samples for lead.

## I. Laboratory Selection

Only a laboratory recognized under EPA's National Lead Laboratory Accreditation Program (NLLAP) should be used for lead-based paint analysis. Such a laboratory is required to use the same analytical methods that it used to obtain accreditation. EPA established NLLAP to provide the public with laboratories that have a demonstrated capability for analyzing lead in paint chip, dust, and soil samples at the levels of concern stated in these *Guidelines*. In some states, an NLLAP laboratory must be used. To participate in NLLAP, a laboratory must:

- Participate successfully in the Environmental Lead Proficiency Analytical Testing Program (ELPAT). ELPAT is administered by the American Industrial Hygiene Association (AIHA) in cooperation with the Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH), and EPA. The proficiency testing samples used in ELPAT consist of variable levels of lead in paint, dust, and soil matrices.
- Undergo a systems audit, including an on-site visit. The systems audit must be conducted by an accrediting organization with a program recognized by EPA through a Memorandum of Understanding (MOU). Laboratory accrediting organizations participating in NLLAP have accrediting program requirements that meet or exceed NLLAP laboratory quality system requirements stated in the MOU.

An up-to-date list of fixed-site and mobile laboratories recognized by the EPA NLLAP for analysis of paint-chip samples may be obtained from the National Lead Information Center Clearinghouse by calling 1-800-424-LEAD or by consulting the Lead Listing at <http://www.leadlisting.org>. Since December 1993, the American Association for Laboratory Accreditation (A2LA) and AIHA have been recognized as laboratory-accrediting organizations participating in NLLAP. NLLAP specifies quality control and data reporting requirements, as described in "Laboratory Quality System Requirements," which can be found in Appendix A of the model MOU. The NLLAP Model MOU can also be obtained by calling the National Lead Information Center Clearinghouse.

**J. Laboratory Report**

The laboratory report for analysis of paint samples for lead should include both identifying information and information about the analysis:

- At a minimum, laboratory identifying information should include the laboratory's name, address, and phone number, as well as NLLAP and other applicable certification and accreditation information.
- Information about the analysis should include the information provided in accordance with NLLAP standards, ASTM E 1613, or the equivalent method(s) used for the analysis of lead.
- Field sample number, laboratory sample number, analytical method, and quality control/quality assurance results.

**VII. Radiation Hazards**

Portable XRF instruments used for lead-based paint inspections contain radioactive isotopes that emit X rays and gamma radiation. Proper training and handling of these instruments is required to protect the instrument operator and any other persons in the immediate vicinity during XRF usage. The XRF instrument should be in the operator's possession at all times. The operator should never defeat or override the safety mechanisms of XRF equipment.

**A. XRF Use Licenses and Certification**

In addition to training and certification in lead-based paint inspection, a person using a portable XRF instrument for inspection must have valid licenses or permits from the appropriate Federal, State, and local regulatory bodies to operate XRF instruments because of radioactive materials contained within. All portable XRF instrument operators should be trained by the instrument's manufacturer. XRF operators should provide related training, licensing, permitting, and certification information to the person who has contracted for their services before an inspection begins. Depending on the State, operators may be required to hold three forms of proof of competency: manufacturer's training certificate, radiation safety license, and a State lead-based paint inspection certificate or license. To help ensure competency and safety, HUD and EPA recommend that owners hire only those inspectors who hold all three.

Which regulatory body is responsible for oversight of the radioactive materials contained in portable XRF instruments depends on the type of material being handled. Some radioactive materials are Federally regulated by the U.S. Nuclear Regulatory Commission (NRC); others are regulated at the State level. States are generally categorized as "agreement" and "non-agreement" States. An agreement State has an agreement with NRC to regulate radioactive materials that are generally used for medical or industrial applications. (Most radioactive materials found in XRF instruments are regulated by agreement States.) For non-agreement States, NRC retains this regulatory responsibility directly. At a minimum, however, most State agencies require prior notification that a specific XRF instrument is to be used within the State. Specifics as to fees and other details regarding the use of a portable XRF instrument vary from State to State. Contractors who provide inspection services must hold current licenses or permits for handling XRF instrument, and they must meet any applicable State or local laws or notification requirements.

Requirements for radiation dosimetry by the XRF instrument operator (wearing dosimeter badges to monitor exposure to radiation) are generally dictated by State regulations and vary from State to State. In some cases, for some isotopes, no radiation dosimetry is required. Because the cost of dosimetry is low, it should be conducted, even when not required, for the following four reasons:

- XRF instrument operators have a right to know the level of radiation to which they are exposed during the performance of the job. In virtually all cases, the exposure will be far below applicable exposure limits.
- Long-term collection of radiation exposure information can aid both the operator (employee) and the employer. The employee benefits by knowing when to avoid a hazardous situation; the employer benefits by having an exposure record that can be used in deciding possible health claims.
- The public benefits by having exposure records available to them.
- The need for equipment repair can be identified.

#### **B. Safe Operating Distance**

XRF instruments used in accordance with manufacturer's instructions will not cause significant exposure to ionizing radiation. But the instrument should never be pointed at anyone, even if the shutter is closed.

The safe operating distance between an XRF instrument and a person during inspections depends on the radiation source type, radiation intensity, quantity of radioactive material, and the density of the materials. As the radiation source quantity and intensity increases, the required safe distance also increases. Placement of materials in the direct line of fire, such as a wall, reduces the required safe distance. According to NRC rules and regulations,<sup>3</sup> a radiation dose to an individual in any unrestricted area must not exceed  $2\frac{1}{2}$  millirems per hour. One of the most intensive sources currently used in XRF instruments is a 40-millicurie  $^{57}\text{Co}$  (Cobalt-57) radiation source. Other radiation sources in current use for XRF testing of lead-based paint generally produce lower levels of radiation. Generally, an XRF operator conducting inspections according to manufacturer's instructions would be exposed to radiation well below the regulatory level.<sup>4</sup> Generally, XRF instruments with lower gamma radiation intensities can use a shorter safe distance provided that the potential exposure to an individual will not exceed the regulatory limit.

Persons should not be near the other side of a wall, floor, ceiling or other surface being tested.

If these practices are observed, the risk of excessive exposure to ionizing radiation is extremely low and will not endanger any inspectors or occupants present in the dwelling.

#### **VIII. REFERENCES - [Note to reviewers: Numbers will be corrected.]**

1. EPA 1995. "A Field Test of Lead-Based Paint Testing Technologies: Technical Report, EPA 747-R-95-002b, May 1995

[1] 10 CFR 1 [NOTE TO REVIEWERS: THE SECTION NUMBER WILL BE CORRECTED.]

May 6, 1997 DRAFT

- 1 [2] U.S. Department of Health, Education, and Welfare, *Radiological Health Handbook*, Bureau of  
2 Radiological Health, Rockville, MD 20852, Revised Edition, January 1970, Publication No. 2016, pp. 131.  
3 [3] State of Wisconsin, Department of Health and Social Services, memo from Mark Chamberlain dated April  
4 28, 1994. Measurements showed that exposures to radiation during operation of a Scitec MAP 3 XRF were 132  
5 rem/day, which can be compared to about 1,400 rem/day from natural background radiation.  
6 [4] US Environmental Protection Agency, A Field Test of Lead-Based Paint Technologies, EPA 747-R-95-  
7 002b, May 1995, US EPA, Washington, DC 20460.

Addendum 1

Examples of Lead-Based Paint Inspections

**A. Example of a Single-Family Housing Inspection**

The inspector completed the "Single-Family Housing LBP Testing Data Sheet," recording "kitchen" as the room equivalent and listing "wood" as the first substrate. The completed inventory of testing combinations in the kitchen indicated the presence of wood, plaster, and metal substrates. Drywall, brick, and concrete substrates were not present in the kitchen. Descriptions of all testing combinations in the kitchen were recorded. Figure 7.1 shows the completed inventory for all testing combinations in the kitchen.

Before any XRF testing, the inspector performed the manufacturer's recommended warm up procedures. The inspector then took three calibration check readings (1.16, 0.99, and 1.07) on the NIST SRM with a lead level of 1.02 mg/cm<sup>2</sup>. The film was placed more than 12 inches away from a painted or other surface. Results of the first calibration check readings were recorded on the "Calibration Check Test Results" form (Figure 7.2).

The inspector then averaged the three readings (1.07) and compared this to the calibration check tolerance obtained from the *XRF Performance Characteristics Sheet* (Figure 7.3). The instrument was within the calibration check limits, so XRF testing could begin.

The inspector recorded the results from the XRF testing in the kitchen on the "Single-Family Housing LBP Testing Data Sheet." The inspector was only able to complete this form through the XRF Reading column (Figure 7.4). The remainder of the form was completed after the testing combinations in the house were inspected and correction values for substrate bias were computed. The inspector then moved on to inspect the next room equivalent.

Two bedrooms and a bathroom were inspected. Three substrates -- wood, drywall, and plaster -- were found in these room equivalents. XRF testing for lead-based paint was conducted, using the same methodology employed in the kitchen. After these four room equivalents were tested, the inspector noticed that all interior doors and all window components had XRF values of more than 5 mg/cm<sup>2</sup>. No further interior door and window components were tested in the remaining room equivalents. All similar remaining untested doors and windows were classified as positive in the final report based on the results of those tested. The raw data for the tested doors and windows were also included in the final report.

After 4 hours from the initial calibration check readings had elapsed, the inspector took another set of three calibration check readings (2.45, 2.21, 2.10) and recorded the results on the "Calibration Check Test Results" form (Figure 7.5). (Many inspections will probably take less than 4 hours; therefore, the second calibration check test would be conducted at the conclusion of the inspection.) The inspector found that the second calibration check (1.24) exceeded the calibration check tolerance on the performance characteristics sheet. The inspector then clearly marked "failed calibration check" on the data sheets for those room equivalents that had been inspected since the last successful calibration check test and consulted the manufacturer's recommendations. The instrument could not be brought back into control, so the inspector began using a backup instrument, after performing a calibration check and manufacturer's warm up and quality control procedure. The results of the calibration check test demonstrated that

the backup instrument was acceptable. The inspector proceeded to reinspect the room equivalents checked with the first instrument. All other room equivalents were inspected using the backup instrument.

Next, because substrate correction was required for all results below 4.0 mg/cm<sup>2</sup> as specified in the *XRF Performance Characteristics Sheet* for the XRF model in use, the inspector prepared to take readings for use in the substrate correction computations. The inspector randomly selected two testing combinations of each substrate where initial readings were less than 2.5 mg/cm<sup>2</sup>, removed the paint from an area on each selected testing combination, took three readings on the bare substrate, and recorded the readings on the "Substrate Correction Values" form (Figure 7.6). The inspector computed the correction values for each substrate by averaging the six readings from the two test locations and recorded the information in the Correction Values row. The correction values were then transferred to the "Single-Family Housing LBP Testing Data Sheet" for each corresponding substrate.

After the inspector had finished taking the readings needed to compute the substrate correction values, another set of three calibration check readings was taken. The inspector recorded the results on the "Calibration Check Test Results" form, under Second Calibration Check, for readings taken by the backup XRF instrument (Figure 7.7). The second (and final) calibration check average did not exceed the 1.0 mg/cm<sup>2</sup> calibration check tolerance. The inspector, therefore, deemed the XRF testing to be complete.

Corrected reading averages were calculated by subtracting the correction value from each XRF result less than 2.5 mg/cm<sup>2</sup> (Figures 7.8 and 7.9). Based on these corrected averages, there were 10 positive results, 2 inconclusive results, and 3 negative results. The two inconclusive results required paint-chip sampling with laboratory confirmation; this resulted in one positive and one negative result. The final summary report included the address of the house inspected; the date(s) of inspection; the starting and ending times for each day of the inspection (Figure 7.10); the name of the inspector (and applicable certification information); the name, address, and phone number of the inspection firm; and compliance information on the lead-based paint disclosure rule.

## **B. Example of Multifamily Housing Inspection**

This section presents a simple example of a multifamily housing development inspection. An actual inspection would have many more testing combinations than are provided here.

The inspector's first step was a visual examination of the development to be tested. During this pretesting review, buildings with a common construction and painting history were identified and the date of construction -- 1948 -- was determined. The construction and painting history of all the units was found to be similar, so that units in the development could be grouped together for sampling purposes. The inspector determined that the development had 55 units, and by consulting Table 7.3, determined that 35 units should be inspected.

The inspector used the "Selection of Units" form (Figure 7.12) to randomly select units to inspect. The total number of units, 55, was entered into the first column of the form. The random numbers generated from a calculator were entered into the second column. The first random number, 0.583, was multiplied by 55 (the total number of units), and the product, 32.065, was entered in the third column. The product was rounded up from 32.065 to 33, and 33 was written in the fourth column, indicating that the 33rd unit would be tested. Other units were selected using the same procedure. If a previously selected unit was chosen again, the inspector crossed out the repeated unit number and wrote "DUP" (for duplicate) in the last column. The inspector continued generating random numbers until 35 distinct units had been selected for inspection. (In this case, it would have been faster to randomly determine the 20 units that would *not* be inspected ( $55 - 35 = 20$ ) and then to select the remaining 35 units for inspection.)

After identifying units to be inspected, the inspector conducted an inventory of all painted surfaces within the selected units. The inspector completed the "Multifamily Housing LBP Testing Data Sheet" for every testing combination found in each room equivalent within each unit. Figure 7.13 is an example of the completed inventory for the bedroom of the first unit to be inspected. The inventory showed that the bedroom was composed of four substrates and eight testing combinations of the following components: (1) one ceiling beam, (2) two doors, (3) four walls, (4) one window casing, (5) two door casings, (6) three shelves, (7) two support columns, and (8) one radiator. Where more than one of a particular component was present, one was randomly selected for XRF testing. Component location descriptions were recorded in the "Test Location" column. Drywall, brick, and metal substrates were not present in the bedroom.

Testing combinations not common to all units were added to the inventory list. The inspector also noted which common areas and exterior areas were associated with the selected units, identified each of these common and exterior areas as a room equivalent, and inventoried the corresponding testing combinations.

The inspector inventoried the remaining 34 units selected and their associated common areas and exterior areas before beginning XRF testing in the development. Alternatively, the inspector could have inventoried each room equivalent as XRF testing proceeded.

After completing the inventory, the inspector performed the manufacturer's recommended warm up and quality control procedures successfully. Then the inspector took three calibration check readings on NIST SRM film. The calibration check was accomplished by attaching the film to a wooden board and holding the board such that the film was in front of the probe. Readings were then taken with the probe at least 12 inches from any other potential source of lead. Calibration check results were recorded on the "Calibration Check Test Results" form (Figure 7.14). The difference between the first calibration check average and 1.02 mg/cm<sup>2</sup> was less than the 1.0 mg/cm<sup>2</sup> calibration check tolerance obtained from the *XRF Performance Characteristics Sheet* (Figure 7.15), indicating that the XRF instrument was in control and that XRF testing could begin. (See the single-family housing example for a description of what to do when calibration check tolerance is exceeded.)

The inspector began XRF testing in the bedroom by taking one reading on each testing combination listed on the inventory data sheet. XRF testing continued until all concrete, wood, and plaster component types were inspected in the bedroom. The XRF readings were recorded on the "Multifamily Housing LBP Testing Data Sheet" form (Figure 7.16). According to the *XRF Performance Characteristics Sheet*, the XRF instrument in use did not require correction for substrate bias, so the XRF classification column was completed at that time. The inspector used single-family housing rules for classifying the XRF readings as positive, negative, or inconclusive. The inspector also used the inconclusive ranges obtained from the *XRF Performance Characteristics Sheet*. The results of the classifications were recorded in the Classification column of the "Multifamily Housing LBP Testing Data Sheet" form. Classifications for all testing combinations within the unit were computed in the same manner as for the bedroom.

Once inspections were completed in all of the 35 selected units of the development, the inspector completed the "Multifamily Housing: XRF Component Type Report" form (Figure 7.18). A description of each component type was recorded in the first column, the total number of each tested component type was entered in the second column, and the number of testing combinations classified as positive for each component type from the "Multifamily Housing LBP Testing Data Sheet" was calculated and entered in the third column. The inspector then did the same for the negative classifications, for inconclusive classifications with XRF readings less than 1.0 mg/cm<sup>2</sup>, and for inconclusive classifications with XRF readings equal to 1.0 mg/cm<sup>2</sup> or greater. Using these numbers and the total number of the component type sampled, the inspector computed and recorded the percentages of positive, negative, and inconclusive classifications for each component type.

After entering the number of testing combinations for each component type in the "Multifamily Housing Component Type Report" form, the inspector noticed that only 34 wood door casings had been inspected. Because it is necessary to test at least 40 testing combinations of each component type, the inspector arranged with the owner to test six more previously untested door casings. Additional units were randomly selected from the list of unsampled units. An initial calibration check test was successfully completed and the six door casings were tested for lead-based paint. Another calibration check test indicated that the XRF instrument remained within acceptable limits. The inspector then updated the "Multifamily Housing: Component Type Report" form by deleting the line that had an insufficient number of component types for testing and including the information on wood door casings on a new line.

The "Multifamily Decision Flowchart" (Figure 7.11) was applied to the component type results. Because 100 percent of the walls and baseboards tested negative for lead, the inspector concluded that no lead-based paint had been detected on any walls or baseboards in the development, including those in uninspected units, and entered "NEGATIVE" in the Overall Classification column. The inspector observed that the percent of positive results was 15 or greater for all of the other component types, with the exception of shelves, hall cabinets, and window casings. Since the flowchart indicated that one or more of these components were coated with lead-based paint, the inspector entered "POSITIVE" in the Overall Classification column. For shelves, hall cabinets, and window casings, XRF results were inconclusive, so the inspector entered "INCONCLUSIVE" in the Overall Classification column. Because three of the component types were classified as "INCONCLUSIVE," the inspector noted from the flowchart that laboratory confirmatory testing of all those components with inconclusive XRF readings equal to or greater than 1.0 mg/cm<sup>2</sup> was required.

The inspector arranged for collection of paint-chip samples from the inconclusive component types, but only from testing combinations where XRF readings were equal to or greater than 1.0 mg/cm<sup>2</sup>. The "Multifamily Housing LBP Testing Data Sheet" was updated to include laboratory results. Paint-chip samples were taken from 28 sampling locations: 9 shelves, 3 window casings, and 16 hall cabinets were classified as inconclusive but had XRF readings equal to or greater than 1.0 mg/cm<sup>2</sup>. The paint-chip samples were collected from a 4-square-inch surface area on each component. Each paint-chip sample was placed in a hard-shelled plastic container, labeled and sealed, and sent to the laboratory for analysis.

The laboratory returned the results to the inspector who entered the laboratory results and classifications on the appropriate "Multifamily Housing LBP Testing Data Sheet" (Figure 7.19). Laboratory results of all nine paint-chip samples taken from the shelves and the three samples taken from the window casings were classified as negative. The results of 5 samples taken from the hall cabinets were classified as positive. The remaining 11 samples were classified as negative.

The "Multifamily Decision Flowchart" was applied to the results shown in the "Multifamily Housing: Component Type Report" to determine the appropriate result for each component type. The inspector classified all shelves and window casings as negative, based either on the XRF-corrected readings or on laboratory confirmation analysis. Therefore, no further action was required for the shelves and window casings. Approximately 8.3 percent (5 confirmed positive results out of the 60 that were inspected) of all hall cabinets in the housing development had lead-based paint.

Final decisions made by the development owner regarding the hall cabinets were based on various factors, including:

- ***The substantially lower cost of inspecting all hall cabinets in the development versus replacing all hall cabinets;***
- ***Future plans, such as renovation or remodeling; and***

- **Requirements regarding the purchase or sale of real estate.**

***In this case, the owner arranged for testing hall cabinets in all of the unsampled units to determine which were positive, and which were negative.***

***To verify the accuracy of the inspection services, the owner asked the inspector to retest 10 testing combinations. The retest was performed according to instructions obtained from the XRF Performance Characteristics Sheet (Figure 7.20). The owner appointed an employee to randomly select 10 testing combinations from the inventory list of 2 randomly selected units. The employee observed the inspector retesting the 10 selected testing combinations, using the same XRF instrument and procedures used for the initial inspection. A single XRF reading was taken from each of the 10 testing combinations. The average of the 10 repeat XRF results was calculated to be 0.674 mg/cm<sup>2</sup>, and the average of the 10 previous XRF results was computed to be 0.872 mg/cm<sup>2</sup>. The absolute difference between the two averages was computed to be 0.198 mg/cm<sup>2</sup> (0.872 minus 0.674). The Retest Tolerance Limit, using the formula described in the XRF Performance Characteristics Sheet (Figure 7.20), was computed to be 0.231 mg/cm<sup>2</sup>. Because 0.198 is less than 0.231, it was concluded that the inspection had been performed competently. The final summary report also included the address of the inspected units, the date(s) of inspection, and the starting and ending times for each inspected unit (Figure 7.21).***